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# Ramifications of excessive use of soybean resistance to the soybean cyst nematode, *Heterodera glycines*

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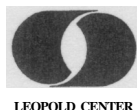
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## Ramifications of excessive use of soybean resistance to the soybean cyst nematode, *Heterodera glycines*

### Principal investigator

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### Budget

\$8,600 for year one  
\$9,000 for year two  
\$9,500 for year three

### Background

Soybean cyst nematode (SCN) is a major problem throughout much of Iowa. Since its discovery in Iowa in 1978, SCN has rapidly spread throughout much of the state. It is currently a major limiting factor in soybean production. In years with adequate rainfall, yield losses due to SCN average 15 to 25%. The potential for losses of 50 to 70% or more exists in drought years.

Although SCN continues to spread throughout the state, and soil population densities are steadily increasing in soils known to be infested, few strategies are available for managing SCN. Nematicides and resistant varieties limit SCN activity and the accompanying yield suppression. However, environmental and human health concerns, coupled with withdrawal of registrations and economic considerations, make nematicide usage an increasingly unfeasible management option.

Host resistance to SCN is the single most effective tool for managing SCN, but even though it is effective and environmentally benign, it is not without problems. The SCN life cycle takes 24 to 30 days under normal field conditions; consequently, several generations of SCN occur per growing season in Iowa. Prolonged planting of SCN-resistant soybean cultivars in the southern United States has resulted in the natural selection of populations or races of SCN capable of reproducing on resistant cultivars. This is because SCN-resistant varieties actually only resist a specific race. If the resistance tactic is overused, SCN populations "select" races capable of reproducing on the resistant varieties (see Fig. 1).

Soybean breeders may benefit from knowing whether genes from different sources of resis-

tance cause changes in SCN races at different rates under natural conditions. Prior to this project, there had been no research in the Midwest to determine whether cultivars carrying different genes for resistance vary in the rapidity in which they cause race shifts.

Once the SCN race change or shift occurs, the resistant cultivar will be less effective for managing SCN. Consequently, it is vital that research be conducted to maintain or improve the effectiveness of SCN-resistant soybean cultivars for managing SCN. In breeding soybean varieties for SCN resistance, soybean breeders use several different soybean genotypes as sources of SCN resistance genes for crosses with soybeans containing other desirable traits. The development of soybean cultivars containing SCN resistance genes that do not cause rapid changes in the SCN race would be helpful to the management program currently available in Iowa. The key to breeding soybean cultivars of this type is to determine under field conditions how rapidly different sources of genes for SCN resistance force a race shift. Because it normally takes up to 10 years to develop a new SCN-resistant soybean cultivar, it is critical that we now identify which source of SCN resistance provides the most durable and effective control. Thus, this project's objectives were

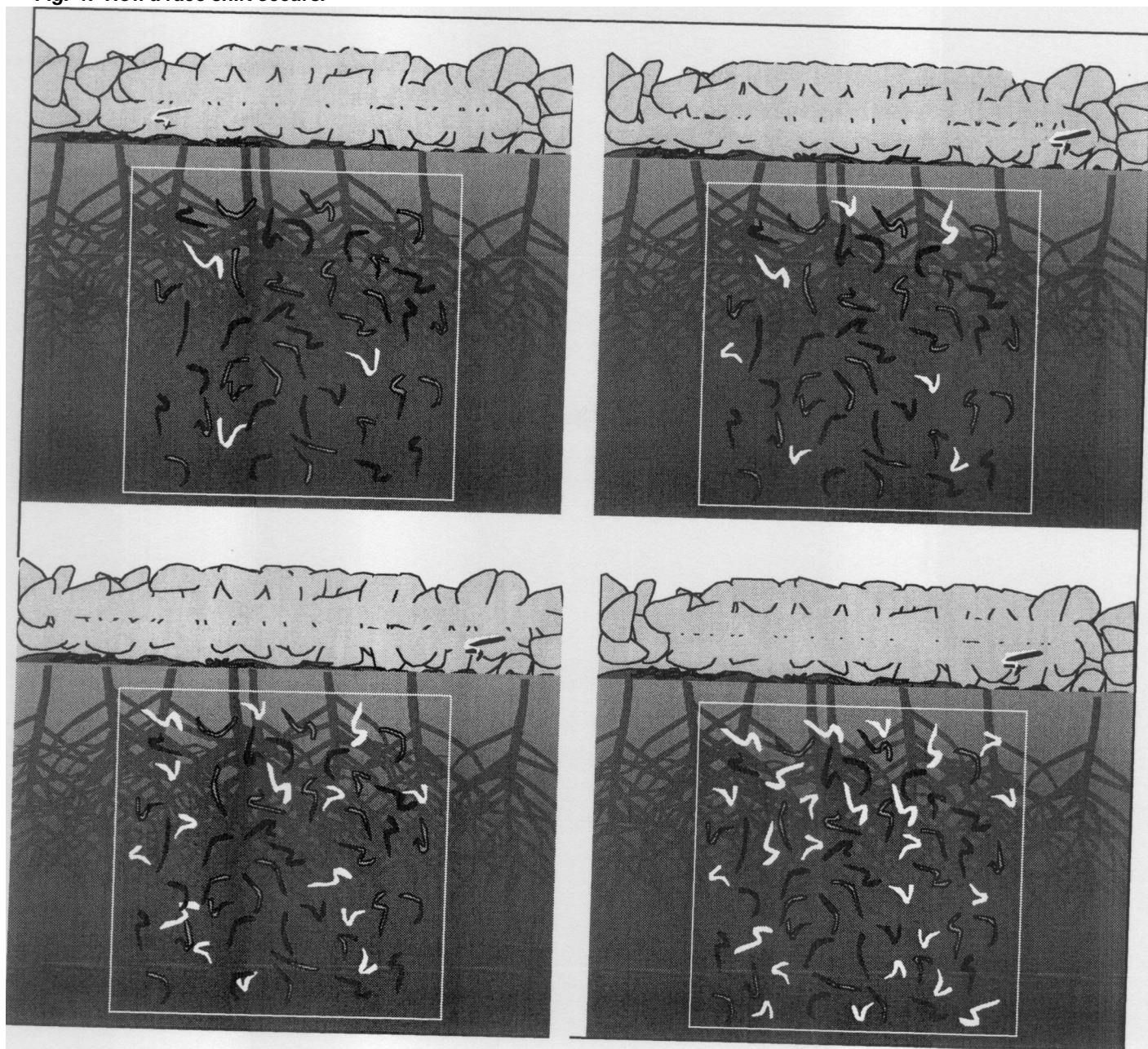
- (1) to detect differences in the rapidity and direction of race shifting in a natural SCN population due to natural selection by resistant soybean genotypes containing different genes for SCN resistance, and
- (2) to correlate race shifts in the SCN population with the genetic source of resistance in order to predict which race will appear after prolonged planting of cultivars containing the different SCN resistance genes.

## Approach and methods

**Genetic materials:** The genetic materials used in this project were the soybean cultivars Jack, Newton, and BSR101, and the plant introduction (a soybean breeding line) PI437654, which is promising for SCN resistance. Currently, there are 16 possible SCN races; races 1 through 6 are most common in Iowa. Newton was released in 1990 because of its resistance to race 3 of SCN. Jack was released in 1989 because of its resistance to SCN races 3 and 4. PI437654, introduced from Russia, has been identified as resistant to all SCN races identi-

fied in the United States to date and currently is being used as a source of resistance genes by breeders across the country. BSR101 is susceptible to SCN; thus, it served as a control treatment. The genes for SCN resistance found in Newton, Jack, and PI437654 constitute most of the genes currently used in breeding SCN-resistant cultivars. Because each resistant genotype used in this experiment has different genes for SCN resistance, investigators anticipated that each may cause a differential selection on the native and genetically mixed SCN population found at the experimental site.

**Fig. 1. How a race shift occurs.**



**Field experiments:** The experiments were conducted in a field naturally infested with SCN located west of Ames. The average SCN population density in the proposed experiment in October 1990 was 1,868 eggs per 100 cubic centimeters (cm) of soil. This site was ideal because the soil had moderate pH and was very flat and well-drained. Small plots consisting of four 18.3-meter rows spaced 76 cm apart were used. The soybean genotypes described above were planted in plots replicated four times in a randomized complete block design. Plots were marked with permanent stakes to facilitate plot establishment in the same location each year. No-till management was employed to minimize movement of SCN-infested soil between plots via farm implements.

**Soil sampling and processing:** Twenty 2.5-cm-diameter, 20-cm-deep soil cores were taken from random locations near the center of each plot. Samples were collected at planting and harvest in the first year, and at harvest only the second and third year. Cores were combined, mixed, and subsampled for SCN egg and juvenile populations. In addition, eggs were collected from cysts and used to inoculate 10 replicate seedlings of each of the five soybean genotypes (four resistant genotypes and one standard, susceptible genotype) used as race differentials. Thirty days later, cysts were dislodged from the soybean roots and counted to determine how well the SCN population reproduced on each differential genotype. Races were determined by a standard scheme. Soil samples were taken at 30, 60, 90, and 120 days after planting, and a subsample of this soil was used to determine SCN egg and juvenile population densities as described above.

## Findings

There were no significant differences in SCN population densities among the four soybean varieties at the beginning of the season. By the end of the season, however, plots planted with the SCN-susceptible variety BSR101 had SCN egg densities more than twice as high as the plots planted with the SCN-resistant soybean varieties (see Table 1). SCN soil population densities continued to increase on BSR101 but decrease on the resistant soybean genotypes throughout the last two years of the project.

Differences in soil population densities observed in fall 1991 remained consistent throughout the subsequent two years of the experiment.

**Table 1. Effects of four soybean varieties on final soybean cyst nematode egg population density and yield at experimental site near Ames, 1991.**

Soybean variety	Final egg density/ 100 cc soil*	Yield (bushels/acre)
Jack	1550 b	45.7 a
Newton	1300 b	40.2 b
PI437654	1525 b	18.6 d
BSR101	3100 a	27.9 c

Values within columns followed by the same letter are not significantly different. \*There were no significant differences in initial SCN egg densities among the four soybean varieties at the beginning of the experiment.

In addition to differences in SCN soil population densities among the four soybean genotypes, there were expected significant differences in yield. Yields for Jack, Newton, PI437654, and BSR101 were 45.7, 40.2, 18.6, and 28.0 bushels per acre, respectively, in 1991. In the subsequent two years, yields gradually decreased for Jack and Newton, but generally stayed the same for PI437654 and BSR101 (see Table 2). However, yields of all four soybean genotypes were consistently significantly different from each other throughout the three years of the project.

**Table 2. Effects of four soybean varieties on soybean yield at experimental site near Ames, Iowa, in 1992 and 1993.**

Soybean variety	Yield (bushels/acre)	
	1992	1993
Jack	42.6	38.1
Newton	41.7	32.3
PI437654	17.2	17.5
BSR101	29.9	27.7

Several races (1, 3, 5, 11, and 13) were detected in the initial soil samples. Race tests on the 1991 harvest soil samples indicated that slight selection for increased ability to reproduce on Jack and Newton had occurred in some, but not all, plots. By fall 1992, the observed race test results had become variable and the trends that had been observed earlier were not as obvious. By fall 1993, SCN soil

population densities were so low that it was difficult to obtain sufficient numbers of eggs to perform race tests. However, race tests were established with the eggs that were available, and the results that were obtained were extremely variable and unreliable.

### Implications

The results of this research did not convincingly support the original hypothesis that different genes for SCN resistance vary in the rapidity with which they produce race shifts. However, the durability of these sources of SCN resistance was not easily evaluated from these experimental results because the SCN populations were decreased so dramatically by the third year of the experiment that race test results were unreliable. Results obtained during the first two years of the project seem to indicate that the SCN resistance genes in Jack and Newton were comparable, with equal potential for causing a race shift, and that

PI437654 may be less prone to induce a SCN race shift.

Results of this research will have an indirect effect on soybean growers throughout Iowa and a direct effect on SCN management recommendations put forth by Iowa State University. Standard SCN management recommendations used by the ISU Plant Disease Clinic include instructions to plant susceptible soybean varieties periodically to reduce the chance of a SCN race shift. *Results from this project indicate that, at least under some conditions, SCN populations may be dramatically reduced before a race shift develops.* Additional experiments are being conducted to confirm the results of this project using different SCN populations at different sites in Iowa. These results indicate that use of SCN-resistant soybean varieties may be a viable long-term, sustainable SCN management option for Iowa soybean growers.

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